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Comparison of Extracorporeal Shock Wave Therapy, Ultrasound and Dexamethasone Iontophoresis in Patients with Lateral Epicondylitis

Lateral Epikondilitli Hastalarda Ekstrakorporeal Şok Dalga Tedavisi, Ultrason ve Deksametazon İyontoforezinin Karşılaştırılması

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Comparison of Extracorporeal Shock Wave Therapy, Ultrasound and Dexamethasone Iontophoresis in Patients with Lateral Epicondylitis

ABSTRACT

Objective: The purpose of this study is to determine the effectiveness of extracorporeal shock wave therapy (ESWT), ultrasound (US), and dexamethasone iontophoresis treatments on pain, grip strength, functionality, and quality of life in patients with lateral epicondylitis, and overdetermine the superiority of the treatments to each other.

Material and Method: This single-blind, prospective study included 78 patients who were diagnosed with lateral epicondylitis. The patients were randomized into three groups. The same physiotherapy program consisted of hot packs, transcutaneous electrical nerve stimulation (TENS), and exercises were administered to all groups. All exercises were performed under the supervision of a qualified physiotherapist. In addition to a 10-day physiotherapy program, every 5 days, a total 3 sessions of ESWT were conducted to the 1st group, 10 days of US applied to the 2nd group, and 10 days of dexamethasone iontophoresis therapy to the 3rd group. Evaluations were carried out before, and 1 month after treatment. Pain severity levels were measured using the numeric rating scale (NRS), disability using the Quick Disabilities of the Arm, Shoulder, and Hand (Quick DASH), quality of life using the Nottingham Health Profile (NHP), and grip strength using a dynamometer and pinch strength using a pinch meter.

Results: The groups were similar in demographic and clinical characteristics. A significant temporal change was found in three groups in terms of pain severity, disability, grip strength, and quality of life at the first month after treatment. When the efficacy of these treatments was compared after treatment in the first month, dexamethasone iontophoresis was statistically superior to US, and ESWT in terms of pain, and quality of life ($p<0.001$, $p=0.007$, $p<0.001$, $p<0.001$ respectively). Also, the US was superior to ESWT in terms of quality of life ($p<0.001$).

Conclusion: Dexamethasone iontophoresis is more effective in functional and clinical improvement in the treatment of patients with lateral epicondylitis.

Keywords: Lateral epicondylitis, ultrasound, dexamethasone iontophoresis, extracorporeal shock wave therapy, tennis elbow

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ÖZET

Amaç: Bu çalışmanın amacı, lateral epikondilitli hastalarda ekstrakorporeal şok dalga tedavisi (ESWT), ultrason (US) ve deksametazon iyontoforez tedavilerinin ağrı, kavrama gücü, fonksiyonellik ve yaşam kalitesi üzerindeki etkinliğini belirlemek ve hangi tedavinin daha etkili olabileceğini belirlemeyi amaçladık.

Gereç ve Yöntem: Bu tek kör, prospektif, randomize çalışmaya lateral epikondilit tanısı konan 78 hasta dahil edildi. Hastalar üç gruba randomize edildi. Bu tek kör, prospektif, randomize çalışmaya lateral epikondilit tanısı konan 78 hasta dahil edildi. Hastalar üç gruba randomize edildi. Tüm gruplar sıcak paketler, transkütanöz elektriksel sinir stimülasyonu (TENS) ve gözetimli egzersizleri içeren bir fizyoterapi programı uygulandı. Tüm egzersizler deneyimli bir fizyoterapist gözetiminde gerçekleştirildi. 10 günlük fizyoterapi programına ek olarak, 1. gruba her 5 günde bir toplam 3 seans ESWT, 2. gruba 10 gün US ve 3. gruba 10 gün deksametazon iyontoforez tedavisi uygulandı. Değerlendirmeler tedaviden önce ve 1 ayın sonunda yapıldı. Ağrı şiddeti sayısal derecelendirme ölçeği (NRS) ile, özürlülük kol, omuz ve el hızlı özürlülük ölçeği (Quick DASH) ile, yaşam kalitesi Nottingham Sağlık Profili (NHP) ile, kavrama gücü dinamometre ile ve parmak gücü pinchmetre ile ölçüldü.

Bulgular: Gruplar demografik ve klinik özellikler açısından benzerdi. Tedaviden sonraki ilk ayda ağrı şiddeti, özürlülük, kavrama gücü ve yaşam kalitesi açısından üç grupta da anlamlı iyileşme saptandı. Tedavi sonrası birinci ayda bu tedavilerin etkinliği karşılaştırıldığında, deksametazon iyontoforez, ağrı, özürlülük ve yaşam kalitesi açısından US ve ESWT'den istatistiksel olarak üstün olarak saptandı (sırasıyla, $p<0.001$, $p=0.007$, $p<0.001$, $p<0.001$). Ayrıca, US yaşam kalitesi açısından ESWT'den daha üstün olarak saptandı ($p<0.001$).

Sonuç: Deksametazon iyontoforezi lateral epikondilitli hastaların tedavisinde fonksiyonel ve klinik iyileşmede daha etkilidir.

Anahtar Sözcükler: Deksametazon iyontoforezi, ekstrakorporeal şok dalga tedavisi, lateral epikondilit, tenisçi dirseği, ultrason

Introduction

Lateral epicondylitis (LE) is one of the most common causes of nontraumatic elbow pain, which develops as a result of repetitive stresses due to overuse of the forearm muscles and is also called tennis elbow (1,2). It has a prevalence ranging from 1-3% in the general population, and the age of onset is generally between 35 and 55 years. It is seen in women, and more frequently on the dominant hand side (3). Typical symptom duration is between 6 and 24 months (4). Previously, lateral epicondylitis was thought to be an inflammatory process, but in some studies, inflammatory cells were not found in histopathological samples, and it was seen as a tendinosis condition that develops as a result of angiofibroblastic degeneration of the forearm extensor muscles (5). Excessive stress on the insertion of the extensor carpi radialis brevis and other extensor muscles is the primary cause of the pathology (6). The main objectives in the treatment of lateral epicondylitis after diagnosis are; relief of pain, accelerating the healing process, reduction of overloading on the elbow joint, and return of the patient to daily life activities (7).

Although conservative, and surgical treatments can be used in the treatment, conservative treatments offer improvement in 95% of the cases. On the other hand, due to the uncertainty about the etiology of lateral epicondylitis, and the pathophysiology of the disease that is not precisely known, no treatment method that can be accepted as the gold standard has not been found (8). Conservative treatment options include rest, patient education, behavior modification, non-steroidal anti-inflammatory drugs, use of splints, ice application, electrotherapy, massage, manual therapy, stretching, and strengthening exercises, extracorporeal shock wave therapy (ESWT), dry needling, balneotherapy, cryotherapy, steroid injections, hyaluronic acid injections, plasma rich platelet injections, and prolotherapy applications (9).

Theuropatic Ultrasound (US) is a conservative treatment method for lateral epicondylitis. By the help of US waves that penetrate to the muscles, blood flow increases in the tissue, the inflammatory mediators that lead to pain and muscle spasms are removed from the tissue and the healing process begins (10).

Another noninvasive method is ESWT. ESWT is commonly used in musculoskeletal pathologies (11). In the ESWT high high-intensity acoustic pressure waves are applied to the tissue within a short period of time. Studies have shown that with the help of ESWT collagen synthesis increases in soft tissues, and tendons, and vascularization accelerates in the tissue also reduces pain (12).

Iontophoresis is another conservative treatment. In iontophoresis, ionized substances are transferred through the skin to the tissues with electrical polarization. Thus, dexamethasone iontophoresis can provide an anti-inflammatory effect without reaching systemic concentrations in the blood (13). By the way, the treatment of lateral epicondylitis without steroid injections may be successful with the help of dexamethasone iontophoresis.

The purpose of our study; is to evaluate the efficacy of ESWT, US, and iontophoresis treatments in terms of pain, grip strength, functionality, and quality of life in patients with lateral epicondylitis and to determine the superiority of the treatments against each other.

Patients and Methods

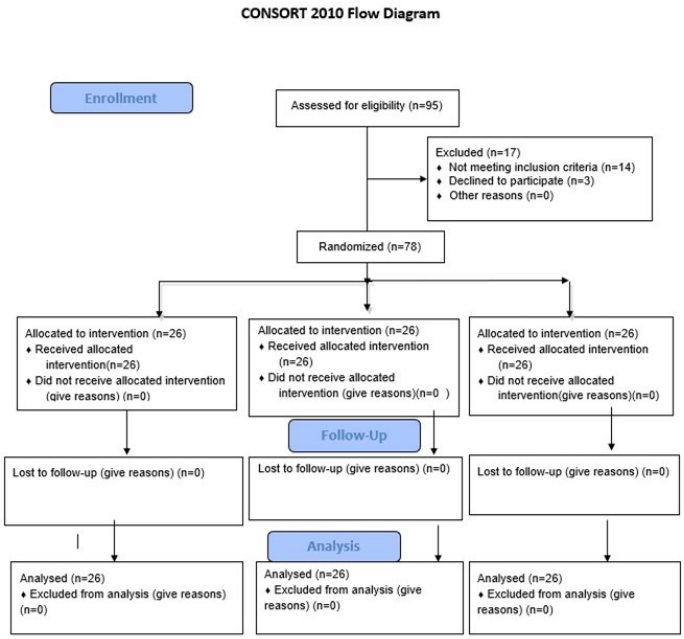
Study Design and Patients

This is a prospective randomized single-blind clinical study. A total of 78 patients aged between 18-65 who were diagnosed with lateral epicondylitis between June 2023 and January 2024 were included in our study. The study was approved by the Hitit University Ethics Committee (14.06.2023 number 2023-77) and written informed consent was obtained from all the patients. The study was carried out in accordance with the principles of the Declaration of Helsinki. The protocol was registered at clinical trials (registration number NCT06189521).

Patients who had chronic pain in the lateral epicondyle for at least four weeks, detection of sensitivity by palpation on the lateral epicondyle, and having positivity in at least two special tests (Cozen test, Maudsley test, and Mills test) were included in the study. Patients with acute pain were not included in the study. Physical therapy, ESWT, or local injections for lateral epicondylitis in the last 3 months, the presence of cervical radiculopathy, carpal tunnel syndrome, other neuropathic diseases,

neurologic diseases, medial epicondylitis, systemic inflammatory diseases, tenderness or swelling at the ipsilateral extremity and fibromyalgia have been excluded. The patients were randomized into three groups by a physiotherapist with sealed envelopes. Clinicians who evaluate patients before and after treatment (specialist physicians P.Ö.B and A.G.D) were blinded to the patient groups. The flow diagram of the patients is shown in Figure I.

Figure 1. Flow Diagram



Treatment Applications

The same physiotherapy program was applied to all groups. The physiotherapy program consisted of hot packs and transcutaneous electrical nerve stimulation (TENS) for 10 minutes and stretching and eccentric strengthening exercises were given to all groups. All exercises were performed under the supervision of the same physiotherapist. Only stretching exercises were performed in the first week and strengthening exercises were added to these exercises in the second week. All patients tolerated the exercises and no patient discontinued the treatment. Paracetamol tablets are prescribed to patients in need due to pain. Paracetamol was prescribed to 6 patients in the ESWT group, 9 patients in the US group, and 7 patients in the control group. Patients were not given splints for LE.

In addition to the 10-day of physiotherapy program, in the first group every 5 days, a total of 3 sessions of ESWT were applied at 1.8 bar, 10.0 Hz, 2000 beats (Elmed Vibrolith Ortho, ESWT-RSWT, Elmed medical systems, USA).

In the second group, 10 days of US were applied at 1.5 watt/cm^2, 1mHz frequency continuous mode to the painful area for 5 minutes, 5 days a week for two weeks (Chattanooga Intelect Advanced Monochromatic Combo 2772, Chattanooga Group, USA).

In the third group, 10 days of dexamethasone iontophoresis therapy were applied. 10 days for 10 minutes. 0,1% dexamethasone ophthalmic pomade was applied to the anodal electrode and placed on the lateral epicondyle and 0.1-0.2 mA/cm^2 galvanic current was applied in each session (ES-522; 2 channel low and medium frequency Electrotherapy, ITO Co. Ltd., Tokyo, Japan).

Clinical Assessments

The clinical and demographic data of the patients were recorded. Numerical rating scale (NRS) was used for the pain assessment. Patients rated their pain from 0 no pain to 10 worst pain (14).

The hand grip strength (Hgs) was measured with a Jamar hydraulic hand dynamometer (Saehan, SH5001) in kilograms. Measurements were done while the patients were sitting in a chair in two positions. In the first position, the patients' elbows were fully extended (Hgs ext), in the second position the patient's elbows were 90 degrees flexed (Hgs flex) without touching the chair. Measurements were made with the affected extremity. The tests were repeated three times with a 30-second rest between them and a mean score was calculated (15).

The strength of the pinch was measured using a hydraulic pinch gauge (Saehan, SH5005) with two points and three points with both hands. At the two points; pinch gauge was placed between the thumb and the lateral part of the second finger. In the three points; the pinch gauge was placed between the second and third finger upside and the thumb downside (16).

Upper extremity disability levels were assessed with the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire. QuickDASH is composed of 11 questions to evaluate daily living activities. Each question is scored from 1 to 5. Higher scores indicate a poorer level of function. The Turkish

version of the test was evaluated (17).

Quality of life was measured by Nottingham Health Profile (NHP). The NHP is made up of 6 subgroups including pain, energy, sleep, social isolation, physical activity, and emotional reactions. The test was composed of 38 questions and the total score ranged from zero to 100 (18).

Statistical Analyses

In the study power analysis performed by examining reference studies in the literature and the sample size to obtain a significant result, the total number of samples was calculated with the parameters effect size =0.79, α error probability =0.05, power (1-β error probability) =0.80 was calculated as totally 76 patients (G-Power v3.1.9.7) (5). Data were analyzed using the statistical package program IBM SPSS Statistics Standard Concurrent User V 29 (IBM Corp., Armonk, New York, USA). Descriptive statistics were given as number of units (n), percentage (%), mean ± standard deviation, median, minimum, maximum, and inter-cartillary distance values. The normal distribution of the numerical variables was evaluated by the Shapiro Wilk normality test. The homogeneity of variances was evaluated by Levene's test. Age, gender, and side variables were compared by one-way analysis of variance and Pearson chi-square analysis. Pre-treatment and treatment numerical variables were compared by groups with repeated measures of two-way analysis of variance if the assumptions were met. Bonferroni correction was applied in all pairwise comparisons. If the assumptions were not met, intergroup comparisons for numerical variables were made by Kruskal-Wallis analysis, and intragroup comparisons were made by Wilcoxon test. The dunn-Bonferroni correction was applied for pairwise comparisons in the Kruskal-Wallis analysis. p<0.05 was considered statistically significant

Results

A total of 78 LE patients were included in the study. Groups are similar in terms of age, sex, and hand dominancy as seen in Table I. No side effects were observed in patients during treatment. In all treatment groups, ESWT, US, and iontophoresis there was a significant decrease in NRS (*p<0.001*) and Quick DASH values (*p<0.001*) between pre-treatment and after treatment one-month follow-up controls. A significant increase was found in the hand grip strength in both elbows 90 degrees flexed (*p<0.001, p=0.013, p<0.001*, respectively) and fully extended (*p=0.001*), and all NHP subgroups at one-month follow-up compared to pre-treatment in all groups. A significant increase was found in two-point and three-point pinch values before and after one-month follow-up in ESWT and iontophoresis groups but not in the US group (Table II).

Table I. Demographic and Clinical Characteristics of the Treatment Groups

	ESWT *n*=26	**Ultrasound** *n*=26	**Iontophoresis** *n*=26	*p*
Age, (*year*)	44.6±7.8 27-59	44.9±7.9 26-63	47.6±5.9 37-60	0.295Φ
Sex, *n* (%)				
Male	**13 (50.0)**	**12 (46.2)**	**15 (57.7)**	**0.698Φ**
Female	**13 (50.0)**	**14 (53.8)**	**11 (42.3)**	
Elbow pain duration (months)	4 (1-9)	5 (1-9)	6 (3-8)	0.067‡
Affected side, *n* (%)				
Left	**11 (42.3)**	**13 (50.0)**	**9 (34.6)**	**0.532Φ**
Right	**15 (57.7)**	**13 (50.0)**	**17 (65.4)**	
Hand Dominancy				
Right	**24 (92.3)**	**24 (92.3)**	**25(96.2)**	**0.635Φ**
Left	**2 (7.7)**	**2 (7.7)**	**1(3.8)**	

n: Number of patients, %: Percentage of columns, age summarized as mean±standard deviation (min-max), pain duration summarized as median (min-max). Φ: One-way analysis of variance, ‡: Kruskal-Wallis analysis, Φ: Pearson chi-square analysis

When the groups were compared with each other, the decrease in NRS levels and Quick DASH values at one-month follow-up was significantly higher in the iontophoresis group than in the ESWT and US group (*p<0.001, p<0.001*), The decrease in NRS values levels and Quick DASH values in ESWT and US groups was not statistically different (*p=0.999*, *p=0.719*, respectively).

The changes in Hgs flex values before and after treatment were statistically different between the groups (*p<0.001*). The increase in Hgs flex values in the iontophoresis group was statistically higher than in the ESWT and US groups (*p=0.001; p=0.038*). The increase in Hgs flex values was not statistically different in the ESWT and US groups (*p=0.607*). The changes in Hgs ext values before and after treatment were statistically different between the

Table II. Comparison of Variables According to Groups

	ESWT				ULTRASOUND				IONTOPHORESİS				Intergroup Comparisons		
	Pretreatment	Aftertreatment	*Difference*	*p**	Pretreatment	Aftertreatment	*Difference*	*p**	Pretreatment	Aftertreatment	*Difference*	*p**	*p*[1]	*p*[2]	*p*[3]
NRS	4.00 (2.25)	2.00 (3.00)^{a}	2.00 (2.25)^{x}	***<0.001***[†]	5.00 (2.25)	3.00 (2.00)^{a}	2.00 (3.00)^{x}	***0.001***[†]	5.00 (2.00)	1.00 (1.25)^{b}	4.00 (2.25)^{y}	***<0.001***[†]	*0.120*[‡]	***<0.001***[‡]	***<0.001***[‡]
QUİCK DASH	50.5±13.0	38.4±12.1	12.1±13.4	***<0.001***[¥]:	55.6±8.2	40.9±11.2	14.6±11.4	***<0.001***[¥]:	54.4±4.8	40.7±9.2	13.5±8.9	***<0.001***[¥]:	*0.131*	*0.657*	*0.719*
HSG FLEX	22.5 (10.2)	24.0 (9.5)	-1.0 (2.0)^{x}	***0.001***[†]	24.0 (9.0)	25.0 (6.7)	-2.0 (5.2)^{x}	***0.013***[†]	23.0 (7.2)	27.5 (6.0)	-3.5 (4.0)^{y}	***<0.001***[†]	*0.965*[‡]	*0.158*[‡]	***0.001***[‡]
HGS EXT	16.0 (6.5)	17.0 (6.0)^{a}	-1.0 (2.2)^{x}	***<0.001***[†]	16.0 (4.0)	21.5 (8.0)^{b}	-5.5 (7.0)^{y}	***<0.001***[†]	16.0 (1.2)	24.0 (5.0)^{b}	-6.5 (4.5)^{y}	***<0.001***[†]	*0.383*[‡]	***<0.001***[‡]	***<0.001***[‡]
TWO POINTS PINCH	4.00 (2.25)	4.50 (2.25)	-0.50 (1.00)	***0.007***[†]	4.00 (2.25)	4.00 (2.25)	0.00 (0.00)	*0.083*[†]	4.00 (1.25)	4.50 (2.00)	-0.50 (1.00)	***0.024***[†]	*0.617*[‡]	*0.979*[‡]	*0.210*[‡]
THREE POINTS PINCH	3.00 (1.00)	4.00 (1.00)	-1.00 (1.00)	***0.002***[†]	4.00 (2.00)	4.00 (0.25)	0.00 (0.25)	*0.132*[†]	3.00 (1.00)	4.00 (1.25)	-1.00 (1.00)	***0.003***[†]	*0.165*[‡]	*0.514*[‡]	*0.198*[‡]
NHP															
Pain	40.30 (5.00)	30.80 (1.50)	10.15 (10.2)	***<0.001***[†]	40.50 (5.28)	30.80 (1.43)	10.20 (4.40)	***<0.001***[†]	41.65 (3.20)	30.85 (1.65)	10.60 (6.20)	***<0.001***[†]	*0.351*[‡]	*0.861*[‡]	*0.592*[‡]
Physical activity	26.60 (5.30)	12.50 (4.00)	12.50 (5.85)	***<0.001***[†]	26.35 (5.80)	12.60 (2.55)	13.15 (4.18)	***<0.001***[†]	26.20 (4.73)	12.15 (1.88)	13.80 (3.80)	***<0.001***[†]	*0.633*[‡]	*0.723*[‡]	*0.795*[‡]
Sleep	38.50 (1.73)	15.45 (3.65)	22.75 (4.15)	***<0.001***[†]	38.95 (2.48)	16.85 (4.20)	21.75 (5.85)	***<0.001***[†]	38.60 (3.20)	15.60 (3.28)	22.70 (5.28)	***<0.001***[†]	*0.412*[‡]	*0.085*[‡]	*0.855*[‡]
Emotional reactions	42.2 (15.1)	23.1 (3.9)^{a}	18.5 (14.1)^{x}	***<0.001***[†]	42.2 (21.7)	13.8 (2.5)^{b}	27.1 (22.8)^{y}	***<0.001***[†]	42.0 (14.4)	13.5 (2.9)^{b}	28.5 (15.1)^{y}	***<0.001***[†]	*0.928*[‡]	***<0.001***[‡]	***0.009***[‡]
Energy	57.5 (16.6)	42.2 (9.9)	14.0 (17.0)^{x}	***<0.001***[†]	58.5 (7.1)	41.9 (8.9)	19.8 (11.2)^{y}	***<0.001***[†]	61.2 (9.6)	40.7 (7.2)	21.5 (10.8)^{y}	***<0.001***[†]	*0.082*[‡]	*0.797*[‡]	***0.006***[‡]
Social isolation	24.0 (1.3)	17.9 (3.3)^{a}	6.1 (3.5)^{x}	***<0.001***[†]	23.6 (2.0)	13.7 (2.3)^{b}	9.9 (3.2)^{y}	***<0.001***[†]	24.0 (1.3)	11.1 (1.9)^{c}	12.3 (2.2)^{z}	***<0.001***[†]	*0.402*[‡]	***<0.001***[‡]	***<0.001***[‡]
Total	211.39(36.5)	186.42(18.7)	38.7(9.2)	***<0.001***[†]	206.42(32.7)	163.21(15.4)	41.3(13.5)	***<0.001***[†]	213.21(41.6)	151.1(16.2)	47.2(14.1)	***<0.001***[†]	*0.120*[‡]	***<0.001***[†]	***<0.001***[†]

Data are presented as mean±standard deviation for normally distributed variables and median (interquartile range) for non-normally distributed variables. PT: Pre-treatment, TS: Post-treatment, Difference=Pre-treatment-Post-treatment, p*: Pre-.treatment and post-treatment comparisons in each group, p1: Comparison between groups before treatment, p2: Comparison between groups after treatment, p3: Comparison of differences between groups before and after treatment, †: Wilcoxon test, ‡: Kruskal-Wallis Analysis, ¥: Two-way analysis of variance in repeated measures, superscripts a, b and c indicate differences between groups after treatment. x, y and z superscripts indicate the difference in the amount of change between the groups before and after treatment. There is no statistical difference between groups with the same superscripts.

groups (p<0.001). The increase in Hgs ext values in the iontophoresis and US group was statistically higher than in the ESWT group (p<0.001; p<0.001). The increase in Hgs flex values was similar in the iontophoresis and US groups (p=0.908) (Table II). Two points and three points pinch parameters did not show a significant difference before and after treatment in all three groups (two points pinch p=0.617, p=0.979, p=0210), (three points pinch p=0,165; p=0,514; p=0,198).

There was no statistically significant difference between the groups before treatment in terms of quality of life. When the groups were compared within themselves at 1 month after treatment, a significant decrease was found in all treatment groups at all NHP subgroups compared to pretreatment (p<0.001) (Table 2). The efficacy of iontophoresis treatment on NHP total was significantly higher than US and ESWT groups (p<0.001; p<0.001) and US was higher than ESWT (p<0,007). The efficacy of iontophoresis treatment on NHP subgroup social isolation was significantly higher than US and ESWT groups (p<0,001; p=0,022) and US was higher than ESWT (p<0,001). Changes in the NHP subgroup's emotional reaction before and after treatment were statistically different between the groups (p=0.009). Changes in NHP emotional reaction in the US and iontophoresis groups were statistically higher than in the ESWT group (p=0.027; p=0.009). The US and iontophoresis groups were statistically similar (p=0.999). Changes in NHP subgroup energy before and after treatment were statistically different between the groups (p=0.006). The US and iontophoresis groups were statistically higher than the ESWT group (p=0.021; p=0.007). US and iontophoresis groups were statistically similar (p=0.999) (Table II).

Discussion

In this study, we evaluated the effects of ESWT, US, and iontophoresis treatments on pain, grip strength, upper extremity functionality, and quality of life of patients with lateral epicondylitis. All treatment modalities were effective in pain, disability and grip strength, and quality of life before and 1 month after treatment. Iontophoresis was superior to ESWT and US in terms of pain and quality of life. US was superior to ESWT in terms of quality of life. To the best of our knowledge, this is the first study to compare the three different treatment modalities ESWT, US, and Iontophoresis in lateral epicondylitis.

After repetitive movements, elbow pain is a common consequence in the general population (19). The condition tends to affect men and women equally (20). Our study included 38 male patients and 40 female patients. It is more common in individuals over 40 years of age (21). In our study, the average age was 47.96±6.78, consistent with the literature. In a study by Ulusoy et al on 304 patients with elbow pain, they found that the right side was affected in 262 patients and the left side in 42 patients (22). They also demonstrated that the dominant side was affected in 252 of these patients. Another study similarly indicated a higher prevalence of involvement on the dominant side in patients diagnosed with lateral epicondylitis (23). In our study, 93.5% of the patients had right-handed dominancy, and 57.6% of them had right elbow involvement.

Exercise is one of the most common treatment options for patients with LE (24). In a previous study, electrotherapeutic modalities with exercise were more effective than electrotherapy alone, therefore we applied an exercise program to all patient groups (25). The exercises were performed under the supervision of a physiotherapist for ten days. By the way, we ensured that patients performed the exercises correctly and adequately. In our study handgrip strength is improved in all treatment groups; however, we did not investigate the efficiency of the exercise program because there is no control group.

Lateral epicondylitis, resulting from overuse of the tendons, is a painful condition associated with tendinopathy, inflammation, pain, and changes in sensitivity in the lateral elbow. Pain leads to a decrease in grip strength, an impairment of upper extremity function, and a reduction in daily life activities. Lateral epicondylitis is common in the general population; however, there is uncertainty in this area; as numerous randomized controlled trials have not provided conclusive evidence for the nonsurgical treatment modalities. The efficacy of dexamethasone iontophoresis in LE was investigated in previous studies (26-29). In a study comparing dexamethasone iontophoresis and galvanic current in 24 patients with LE, they found that the iontophoresis group had a more significant reduction in pain levels and improved strength and functionality compared to the galvanic current group. [26] Another study with dexamethasone iontophoresis (n=43) showed a significant reduction in pain levels compared to placebo (n=42) and was effective in improving function (27). Akhondali et al compared iontophoresis and Cyriax technique in 22 patients with LE, groups were similarly improved in terms of pain, grip strength, and patient daily activities (28). In a study comparing the effectiveness of iontophoresis and phonophoresis, it was found that iontophoresis was more effective on pain, upper extremity functions, and grip strength (29). Iontophoresis has also been studied in other patient groups. In a study conducted on patients with subacromial impingement syndrome, iontophoresis was found to be more effective in clinical and functional recovery, and also in pain parameters compared to the control group, in another study conducted on patients with knee osteoarthritis, iontophoresis, and galvanic current were found to be more effective in reducing pain than the classical physical therapy program and also iontophoresis was found to be more successful than galvanic current in reducing pain and cyst volume (30,31). This may be the result of the anti-inflammatory effect of dexamethasone.

There is no clear consensus in the literature on the superiority of ESWT and US therapy in LE. In the study by Dedes et al ESWT has been shown to be more effective than US therapy in relieving pain, improving function, and increasing activity in LE (32). Similar results were reported by Kubot et al (33). A meta-analysis suggested that ESWT is superior to US in the treatment of LE (34). However, Yalvaç et al found that while ESWT and US were effective for improving quality of life, upper extremity functioning, grip strength, and reducing pain ESWT was not

superior to US (5). In a previous study, ESWT was combined with topical corticosteroids, there was no significant difference with topical steroids, but pain and hand grip strength improved in both groups (35). In our study, the application of steroids with galvanic current is superior to ESWT.

In the literature, we did not find any study comparing the effectiveness of iontophoresis, ESWT, and US in lateral epicondylitis. In our study, all three treatment modalities were effective in pain and upper extremity functioning, and quality of life compared to pretreatment levels at 1 month follow-up. However, the iontophoresis group showed a significant improvement in pain, upper extremity functioning, and quality of life compared to the ESWT and US groups. When comparing the US and ESWT groups, the improvement in quality of life was higher in the US group.

The limitations of our study include the lack of long-term follow-up, and patients evaluated shortly after the end of the treatment program. The same physical therapy program was applied to all patients and we did not evaluate the effects of physical therapy. Patients were not blinded to the treatment.

The strengths include being conducted at a single center, diagnosis, and treatment initiation by the same physiatrist, and being the only study comparing all three treatment groups. Iontophoresis, US, and ESWT applications have been found to improve pain, function, grip strength, and quality of life in patients with LE. Among these three applications, dexamethasone iontophoresis was superior to the US and ESWT. We believe that studies with a placebo group, involving longer follow-up would be beneficial to examining the effectiveness of treatments.

In conclusion, dexamethasone iontophoresis is more effective in functional and clinical improvement in the treatment of patients with lateral epicondylitis compared to US and ESWT.

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